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The oldest *Pinus nigra* plantations in the central Apennines: distribution and floristic-vegetational characterisation

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Abstract

This paper represents the first syntaxonomic study on the *Pinus nigra* subsp. *nigra* artificial stands in the Apennines. It refers exclusively to the mature *Pinus nigra* forest plantations in the central Apennines that were planted before the 1950s, and then not managed. The mature *Pinus nigra* forest plantations in the central Apennines are distributed within four National Parks, on limestone substrata, mainly with southern aspects and rugged slopes, and at elevations ranging from 655 m to 1670 m a.s.l.. Two new phytosociological associations are described here and classified in the alliance *Junipero communis–Pinion nigrae*: *Orthilio secundae–Pinetum nigrae* and *Digitalidi micranthae–Pinetum nigrae*. The association *Orthilio secundae–Pinetum nigrae* comprises the relative mesophilous mature pine forests of the supratemperate thermotype in the plant landscape context of the alliance *Aremonio agrimonioidis–Fagion sylvaticae* potential vegetation belt. The *Digitalidi micranthae–Pinetum nigrae* comprises the thermophilous pine forests occurring on rocky stands within mesotemperate and lower supratemperate thermotypes in the potential belt of alliance *Carpinion orientalis* woods. The comparison of these two new associations and the phytosociological literature concerning the natural communities of *Pinus nigra* in the Apennines highlights their floristic and coenological autonomy.

Keywords

distribution, mature forest plantation, phytosociology, *Pinus nigra* subsp. *nigra*, syntaxonomy, vegetation

Introduction

Pinus nigra J.F. Arnold is a collective species with a wide but fragmented distribution that extends from north-west Africa through southern Europe to Anatolia and the northern Black Sea region, predominantly in mountain areas (Enescu et al. 2016). On the Italian peninsula, the indigenous *Pinus nigra* s.l. populations belong to two taxa: *Pinus nigra* subsp. *nigra* (eastern Alps and central-southern Apennines), which includes the variety italica of the subsp. *nigra* recognized for the steeper slopes of a few sites in the Abruzzo region (Bruschi et al. 2006), and *Pinus nigra* subsp. *laricio* (southern Apennines and Sicily) (Bartolucci et al. 2018). These are included in priority habitat 9530*: (sub-) Mediterranean pine of endemic black pines – (sub-) Mediterranean pine forests with endemic black pines (Habitat Directive 92/43/EEC).

At the syntaxonomic level, the communities dominated by *Pinus nigra* s.l. in the mountain systems of the Mediterranean basin are currently referred to two classes: *Junipero-Pinetea sylvestris* and *Erico-Pinetea* (Mucina et al. 2016). The class *Junipero-Pinetea sylvestris* refers to the relict oromediterranean and submediterranean orotemperate dry pine forests, juniper woods and related scrub of the Mediterranean. A recent phytosociological study of the forests dominated by *Pinus nigra* subsp. *pal-*

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lasiana confirmed the order *Berberido creticae-Juniperetalia excelsae* of the class *Junipero-Pinetea sylvestris* for the Mediterranean Turkey (Kavgacı et al. 2021). The class *Erico-Pinetea* refers to the relict pine forests and related scrub on calcareous and ultramafic substrates of the Balkans, the Alps, the Carpathians and Crimea.

A recent syntaxonomic revision of the order *Erico-Pinetalia* for the Apennines-Balkan province allowed the proposal of the new order *Junipero communis-Pinetalia nigra*e within the class *Erico-Pinetea* class (Biondi & Allegrezza 2020). The order *Junipero communis-Pinetalia nigra*e represents the vicariant of the order *Erico-Pinetalia* in the central-southern Apennine-Balkan mountain ranges.

For the Italian peninsula, the class *Junipero-Pinetea* is considered exclusively for the *Pinus nigra* subsp. *laricio* communities of the supraMediterranean belt of Sicily and Calabria, on siliceous or metamorphic substrate. As far as *Erico-Pinetea*, is concerned, two orders are currently considered in the EuroVegChecklist: *Erico-Pinetalia*, with the alliances *Erico carneae-Pinion* Br.-Bl. in Br.-Bl. et al. 1939 nom. invers. propos. Mucina et al. 2016, and *Erico-Fraxinion orni* Horvat 1959 nom. invers. propos. Mucina et al. 2016, for the central Alps (Armiraglio et al. 2006) and the south-eastern Alps (Poldini 1969; Dakskobler 1999), respectively; and *Junipero communis-Pinetalia nigra*e Biondi et Allegrezza 2020, with the alliance *Junipero hemisphaericae-Pinion nigra*e Biondi et Allegrezza 2020, for the central-southern Apennines (Biondi & Allegrezza 2020).

In the Apennines, *Pinus nigra* has been widely used for extensive plantations of non-forested areas since the early 1900s (Amorini & Fabbio 1992; Nocentini 1999). Most of these areas were originally covered by deciduous forests, but intensive grazing and farming had destroyed the original forest cover. The forests plantation was necessary as a response to the marked hydrogeological instability that has affected wide areas of the Apennines since the end of 1800s, and in particular the montane south-facing slopes where the anthropogenic effects over the centuries have been more intense (Bonanomi et al. 2018). In general, these artificial stands were not managed, and thus they underwent the natural dynamic processes of restoration by the native vegetation, as seen particularly for mature pine plantations (Allegrezza et al. 2013; Ottaviani et al. 2015; Bonari et al. 2021).

Although the pine plantations are included as forest ecosystems in the Apennines ecoregion (C39_ Peninsular and Sicilian mountain supra and oroMediterranean forest ecosystems dominated by *Pinus nigra*, *P. leucodermis* and/or *P. laricio*) (Capotorti et al. 2020), except for a few studies (e.g., Ottaviani et al. 2015), these stands have not been investigated from a floristic-vegetational point of view, because they represent artificial communities. Moreover, no syntaxonomic studies for Italy are currently available. However, there have been syntaxonomic studies relating to the communities of conifer plantations in France (Royer et al. 2006; Royer 2010), where the alliance *Epipactido muelleri-Pinion sylvestris* has been described for *Pinus sylvestris* old artificial stands, to separate them from *Pinus sylvestris* natural communities mainly referred to the *Erico carneae-Pinion* alliance, although the same author reports a similar floristic pool from comparisons of natural versus artificial stands. The alliance *Epipactido muelleri-Pinion sylvestris* was recently included as syntax. syn. in *Erico carneae-Pinion* (Relict *Pinus sylvestris* forests on calcareous substrates of the Alps, the Hercynicum and the Massif Central), in the context of the class *Erico-Pinetea* (Mucina et al. 2016). This means no significant floristic differences at the level of alliance resulted from the comparison of the artificial and natural *Pinus sylvestris* communities. As a consequence, the European syntaxonomic revision includes the pine communities of natural and artificial origin in the same syntaxonomic alliance *Erico carneae-Pinion* (Mucina et al. 2016).

Owing to the maturity and complexity of pine forest plantations in the Apennines, it would be legitimate to ask: does it make sense to compare natural and artificial communities with each other, and to trying to classify these artificial ones in phytosociological terms? With regard to the mature pine forests, we would say yes. As these are very old (almost centenarians) and have now reached full structural and biological complexity, and as they have also undergone renewal, which indicates the stability of these coenoses over time. The structure of these communities after a century, is no longer orderly, of the same age and monoplane as in a planted stand, and the forest dynamics are now completely natural, with the presence of renewal and crashes / re-closure of the clearings. On the basis of this (by now) reached naturalness, they fall within the same vein of the Aleppo pine and chestnut woods, probably planted and now treated as natural also from a phytosociological point of view. Furthermore, *Pinus nigra* was not a foreign plant in the Apennines as shown by the numerous palynological (Marchesoni 1957; Brugiapaglia & Beaulieu 1995) and biogeographic (Biondi & Allegrezza 2020) studies.

Thus the objectives of this study that focussed on mature *Pinus nigra* plantations were: (i) to shed light on the distribution of the oldest artificial stands (planted before 1950) in the central Apennines at elevations above 600 m a.s.l., which are not managed; (ii) to perform a floristic-vegetational analysis and a syntaxonomic classification; and (iii) to highlight similarities and differences between the pine forests of anthropogenic origin identified in this study and the syntaxa of the *Pinus nigra* subsp. *nigra* natural forests described in the literature for the Apennines.

Material and methods

Study area

The study area included the Apennine and pre-Apennine ridges of central Italy, from Mount Carpegna in the North (43°48'04.32"N, 12°19'13.44"E) to Villetta Barrea in the South (41°46'36"48 N, 13°56'21"84 E), at elevations

over 600 m a.s.l. (Fig. 1). The bioclimatic classification sensu Rivas-Martínez et al. (2011) indicated a temperate macrobioclimate, oceanic bioclimate and thermotype from upper mesotemperate to upper supratemperate (Pesaresi et al. 2014). From a geological point of view, the investigated territories all fall within the limestone domain.

Selection of the oldest *Pinus nigra* plantations

The selection of the oldest *Pinus nigra* plantations (planted before 1950) were documented through the cartography of the Istituto Geografico Militare (Military Geographical Institute), and forest archives and historical photos. The pure plantations of *Pinus nigra* subsp. *nigra* that had not been managed for many years were then selected by exploratory field surveys.

Vegetation analysis

The vegetation study was conducted according to the phytosociological method (Braun Blanquet 1928) for a total of 59 phytosociological relevés, of which 41 were not published, 8 were published (Allegrezza et al. 2013; Ottaviani et al. 2015) and 10 were used in a previous study (Allegrezza et al. 2020). The nomenclature of the species follows Bartolucci et al. (2018) with exception for *Juniperus communis* and *Quercus pubescens*, while their biological and chorological features make reference to Pignatti (1982) and Pignatti et al. (2017–2019). A comparison with the natural *Pinus nigra* subsp. *nigra* communities already described in the literature is shown through a specific synoptic table (Table 1). The syntaxonomic nomenclature follows the Prodrome of Italian Vegetation (Biondi et al . 2014, 2015), and the recent revision of *Pinus nigra* subsp. *nigra* communities in the Apennines and the Balkan province (Biondi & Allegrezza 2020). References for the class *Loiseleurio procumbentis-Vaccinietea* and the epithet and authors of the class *Erico-Pinetea* and order *Erico-Pinetalia* were made to the Vegetation of Europe (Mucina et al. 2016).

Statistical analysis

Braun-Blanquet's cover-abundance values were transformed according to the Van der Maarel scale (Van der Maarel 1979), and were then subjected to multivariate analysis through the use of the VEGAN community ecology package (Oksanen et al. 2015). Classification of the relevés obtained from the cluster analysis was carried out by applying the algorithm of the average linkage (Orloci 1978) on the similarity matrix, calculated by applying the Bray-Curtis Index. Non-metric multidimensional scaling (NMDS) was used to describe the main trends in the floristic variations. Furthermore, the "indicspecies" R package (De Cáceres & Legendre, 2009) was used to determine the Pearson association coefficient (phi) (Chytrý et al., 2002), in order to identify the species significantly associated with the different *Pinus nigra* subsp. *nigra* communities (Suppl. material, Table S3).

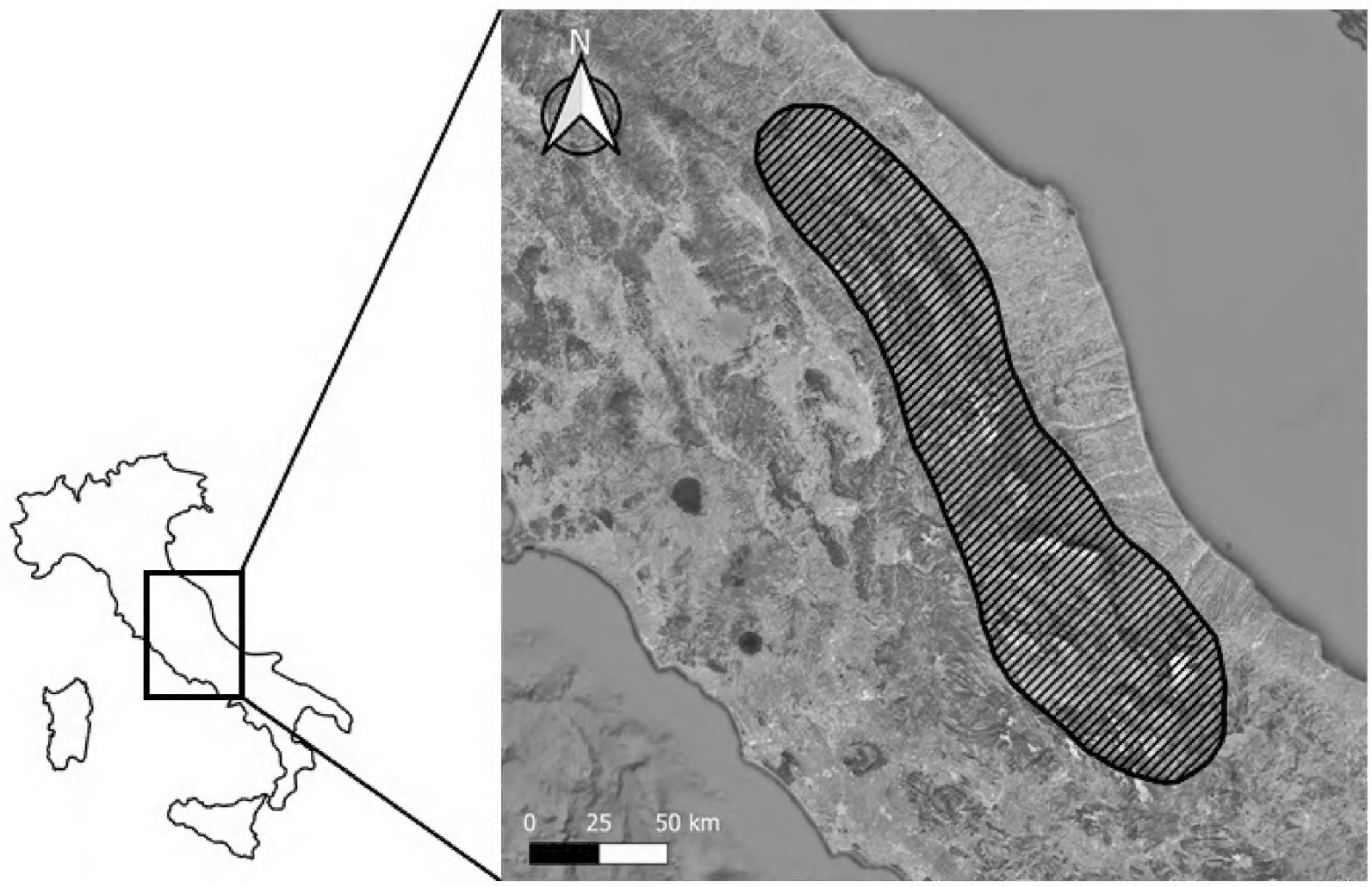

Figure 1. Location of the study area in Italy.

Results and discussion

Distribution of the oldest *Pinus nigra* plantations

The mature *Pinus nigra* plantations were located within four National Parks (Monti Sibillini; Gran Sasso and Monti della Laga; Maiella; Abruzzo, Lazio and Molise) and three Regional Natural Parks (Sasso Simone and Simoncello; Gola della Rossa and Frasassi; Sirente-Velino). The elevation was from 655 m a.s.l. (Mount Predicatore) to 1670 m a.s.l. (Mount Bove). The exposure was mainly southern, with slopes from 25° to 45°. The oldest plantation was located in Villetta Barrea (planted before 1900) in the Abruzzo-Molise National Park, followed by Mount Roio (planted in 1900) near the town of L'Aquila, finally to Mount Predicatore (planted in 1914-1916) in the Regional Natural Park of Gola della Rossa and Frasassi. The natural forest context was mainly represented by mixed deciduous forests (order *Quercetalia pubescentis-petraeae*) at the lower elevations (up to ~1100 m a.s.l.) and by beech forests (order *Fagetalia sylvaticae*) at the upper elevations (above ~1100 m a.s.l.) (Allegrezza et al. 2020).

Definition of the vegetational types and the floristic composition

The dendrogram shown in Figure 2A was obtained from the classification of the phytosociological relevés, which were separated into two main groups, as Cluster I and Cluster II. The NMDS ordination (Fig. 2B) confirmed the separation of the clusters of the dendrogram. Cluster I includes the phytocoenoses of *P. nigra* present in the supratemperate thermotype, while Cluster II includes the *P. nigra* communities in the upper mesotemperate and lower supratemperate. The processing of the relevés and the comparisons with the literature data (Table 1) allowed us to propose two new associations in the alliance *Junipero hemisphaericae-Pinion nigra*e. These correspond to the dendrogram clusters and the NMDS ordination diagram (Fig. 2): *Orthilio secundae-Pinetum nigrae* (Table S1 in Supplementary material), and *Digitalidi micranthae-Pinetum nigrae* (Table S2 in Supplementary material). For both of these communities investigated, they are proposed to belong to Habitat 9530* "(sub-) Mediterranean pine forests of endemic black pines", which groups the Mediterranean montane and alpine forests characterised by the dominance of pines of the *Pinus nigra* group (Habitat Directive 92/43/EEC).

*ORTHILIO SECUNDAE-PINETUM NIGRA*E ass. nov.
Suppl. material 1, Table S1: rels 1–32; *typus* rel. 5: Godi Mountain locality (Abruzzo, Lazio and Molise National Park), Implantation date (before 1900); Elevation (1000 m a.s.l.); Aspect (South); Slope (25°): Area (100 m²); Cover (90%);

Characteristic and differential species of the association *Orthilio secundae-Pinetum nigra*e: *Pinus nigra* subsp. *nigra* 4, *Cytisus spinescens* 3, *Orthilia secunda* 1, *Globularia meridionalis* 2, *Cephalanthera rubra* +; differential species of the subassociation *typicum*: *Carex humilis*. 1, *Polygala chamaebuxus* 1, *Asperula purpurea* +; Characteristic and differential species of the alliance *Junipero hemisphaericae-Pinion nigra*e, order *Junipero communis-Pinetalia nigrae*, and class *Erico-Pinetea*: *Fraxinus ornus* +, *Sorbus aria* 1, *Juniperus communis* (s.l.) 2, *Amelanchier ovalis* +, *Lomelosia crenata* ssp. *pseudisetensis* 2; Other species: *Bromopsis erecta* +, *Rosa canina* (s.l.) +, *Acer monspessulanum* 1, *Euphorbia cyparissias* 1, *Pimpinella tragium* +, *Lotus corniculatus* +, *Centaurea ceratophylla* 1, *Hippocrepis glauca* +, *Pilosella officinarum* 1. *Thymus striatus* ssp. *acicularis* 1, *Anthericum liliago* +; *Koeleria splendens* +; *Dianthus longicaulis* +, *Leontodon crispus* 1, *Linum tenuifolium* 1.

*ORTHILIO SECUNDAE-PINETUM NIGRA*E subass. *TYPICUM*

rels 1–16; *typus* rel. 5: the same relevé reported before.

AMELANCHIERETOSUM OVALIS subass. nov.

rels 17–24; *typus* rel. 21: near Arischia (AQ) Gran Sasso e Monti della Laga National Park, geographic coordinates (33T 363875m E, 4699852m N), Implantation date (1930); Elevation (1205 m a.s.l.); Aspect (South-South-East); Slope (35°): Area (300 m²); Cover (85%);

Characteristic and differential species of the association O*rthilio secundae-Pinetum nigrae*: *Pinus nigra* subsp. *nigra* 3, *Cytisus spinescens* 2, *Orthilia secunda* +, *Cephalanthera rubra* +; differential species of the subassociation *amelanchieretosum ovalis*: *Amelanchier ovalis* 1, *Cotoneaster tomentosus* +, *Viburnum lantana* +, *Lonicera caprifolium* +, *Festuca stricta* subsp. *trachyphylla* +, *Acer campestre*, *Inula hirta* +; Characteristic and differential species of the alliance *Junipero hemisphaericae-Pinion nigra*e, order *Junipero communis-Pinetalia nigra*e, and class *Erico-Pinetea*: *Fraxinus ornus* 1, *Sorbus aria* 1, *Juniperus communis* (s.l.) +, *Cytisophyllum sessilifolium* 2, *Juniperus deltoides* +; Species from the class *Querco-Fagetea*; *Fagus sylvatica* +, *Acer opalus* subsp. *obtusatum* +, *Hieracium murorum* (s.l.) + *Quercus cerris* 1, *Viola alba* subsp. *dehnhardtii* 1, *Neottia nidus-avis* +, *Solidago virgaurea* +, *Hepatica nobilis* +; Other species: *Bromopsis erecta* +, *Teucrium chamaedrys* +, *Asperula purpurea* +, *Dactylis glomerata* +, *Knautia calycina* +, *Hypericum perforatum* +, *Pimpinella saxifraga* +, *Carlina vulgaris* +, *Pilosella piloselloides* +, *Rosa arvensis* +, *Acer platanoides* +, *Fraxinus excelsior* 1, *Globularia bisnagarica* +, *Salvia pratensis* 1);

SANICULETOSUM EUROPAEAE subass. nov.

rels 25–32; *typus* rel. 25: Rel. 25: Bove Mountain locality, Sibillini National Park, geographic coordinates (33T 351231m E, 4752040m N), Implantation date (1930); Elevation (1590 m a.s.l.); Aspect (South); Slope (35°): Area (300 m²); Cover (95%);

Characteristic and differential species of the association *Orthilio secundae-Pinetum nigrae*: *Pinus nigra* subsp. *nigra* 4, *Orthilia secunda* 1, differential species of the subassociation *saniculetosum europaeae*: *Sanicula europaea* +, *Cephalanthera longifolia* 1; Characteristic and differential species of the alliance *Junipero hemisphaericae-Pinion nigrae*, order *Junipero communis-Pinetalia nigrae*, and class *Erico-Pinetea*: *Sesleria nitida* +, *Juniperus communis* (s.l.) +; Species from the class *Querco-Fagetea*: *Fagus sylvatica* 2, *Acer opalus* subsp. *obtusatum* +, *Hieracium murorum* (s.l.) 1, *Acer pseudoplatanus* +, *Epipactis helleborine* +, *Ostrya carpinifolia* +, *Neottia nidus-avis* +, *Festuca heterophylla* +, *Quercus pubescens* (s.l.) +, *Acer campestre* +; Other species: *Brachypodium rupestre* +, *Rosa canina* (s.l.) +, *Teucrium chamaedrys* +, *Asperula purpurea* +, *Lotus corniculatus* +, *Digitalis micrantha* +, *Pilosella piloselloides* +, *Medicago lupulina* +.

The new association *Orthilio secundae-Pinetum nigrae* includes mature plantations of *Pinus nigra* subsp. *nigra* on the slopes of the limestone reliefs of the central Apennines,

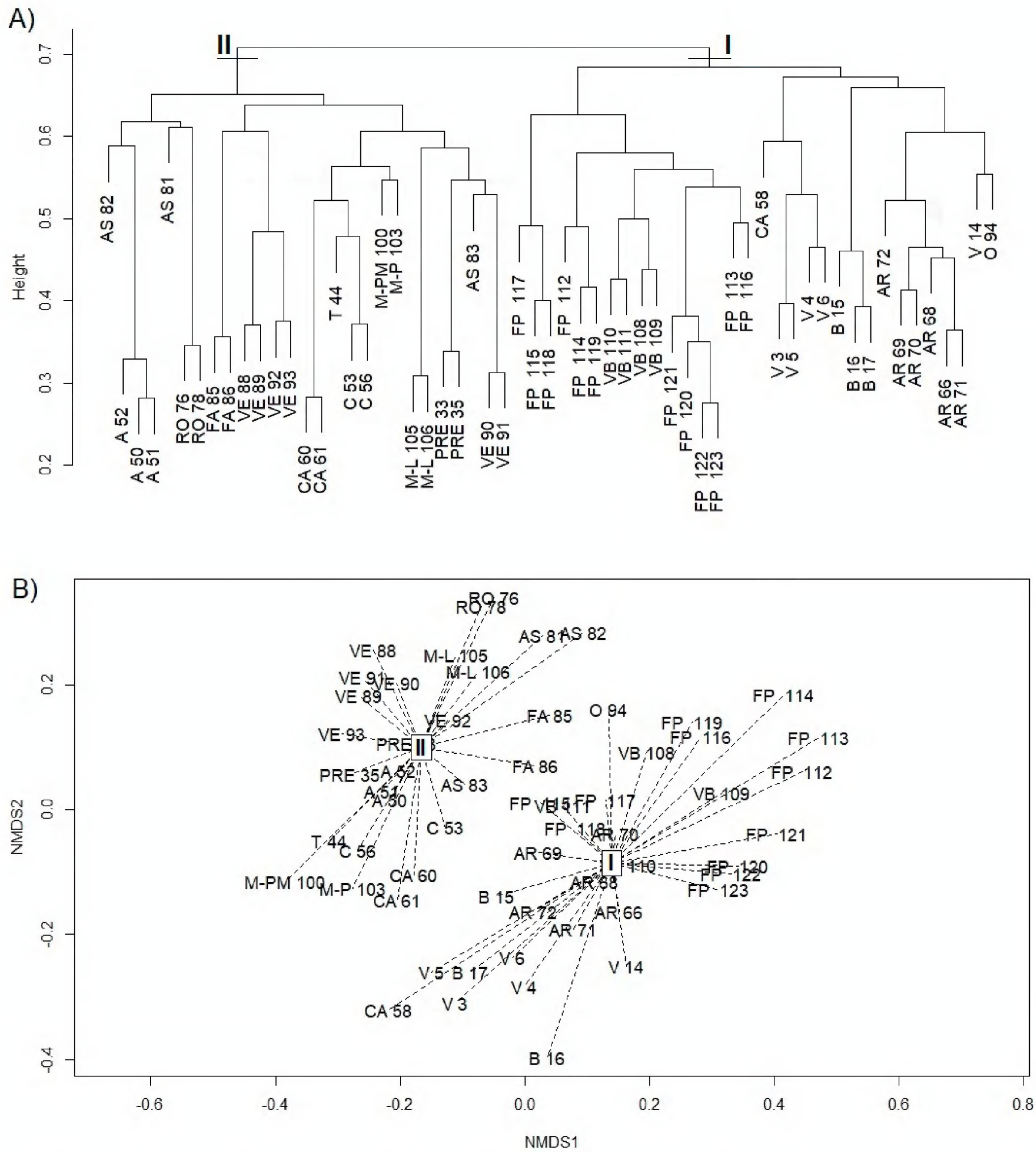

Figure 2. Dendrogram A) and non-metric multidimensional scaling ordination (stress 0.24) B) of the phytosociological relevés of the mature *Pinus nigra* plantations in the study area: *Orthilio secundae-Pinetum nigrae* [(cluster I in A); group I in B)], and *Digitalidi micranthae-Pinetum nigrae* [(cluster II in A); group II in B)].

with predominantly southern exposure and the optimum in the supratemperate thermotype in the context of the potential of the beech forests of the alliance *Aremonio agrimonioidis-Fagion sylvaticae*. The preferential dynamic contacts are with the vegetation shrubs of the alliance *Berberidion vulgaris* and with the secondary grasslands of the alliance *Phleo ambigui-Bromion erecti* and/or the *Cytiso-Satureion montanae* and *Cerastio tomentosi-Globularion meridionalis* garrigues. Sometimes where there are rocky conditions at the upper limit of the woods, the pine forests of the new association *Orthilio secundae-Pinetum nigrae* are in contact with the shrubby coenoses of *Juniperus communis* subsp. *nana* from *Daphno oleoidis-Juniperion alpinae* (class *Loiseleurio procumbentis-Vaccinietea*). These pine forests have an uneven structure, with a mean height of 15 m to 20 m, with *Pinus nigra* dominant (cover from 70%–90%) and a mean of 25.6 species per relevé. As well as *P. nigra*, some deciduous trees can be found in the shrubby layers (upper and lower), such as *Fraxinus ornus*, *Sorbus aria*, *Fagus sylvatica*, *Acer obtusatum* subsp. *obtusatum*, *Ostrya carpinifolia*, *Quercus cerris* and others, and juniper (*Juniperus communis* s.l., *J. delthoides*). The herbaceous layer is mainly represented by chamaephytic species, some of which are common in natural pine forests (*Orthilia secunda*, *Polygala chamaebuxus*) and others of which are typical of grasslands and garrigue (*Asperula purpurea*, *Cytisus spinescens*, *Globularia meridionalis*). However, there are also hemicriptophytes of heliophilous edges (*Brachypodium rupestre*) and grassland species (*Bromopsis erecta*, *Carex humilis*, *Sesleria nitida*). In addition, renewal of the pine is well represented, with its presence in 24 relevés out of a total of 33. The characteristic and differential species of the new association are considered to be: *Pinus nigra* subsp. *nigra*, *Orthilia secunda*, *Polygala chamaebuxus*, *Epipactis helleborine* and *Cephalanthera rubra*. The new association *Orthilio secundae-Pinetum nigrae* is referred to the central-southern Apennines alliance *Junipero hemisphaericae-Pinion nigrae*, order *Junipero communis-Pinetalia nigrae*, of the class *Erico-Pinetea*.

As part of the new association *Orthilio secundae-Pinetum nigrae* (Suppl. material, Table S1), we can recognize three subassociations: *typicum* (rels 1–16), *amelanchieretosum ovalis* (rels 17–24) and *saniculetosum europaeae* (rels 25–32).

Orthilio secundae-Pinetum nigrae subassociation *typicum* (rels 1–16) represents the more stable and mature aspect of the *Pinus nigra* plantation in the central Apennines in the supratemperate thermotype. Specifically, it refers to the ancient *Pinus nigra* stands (most planted before 1900) in the Abruzzo, Lazio and Molise National Park in the south-western part of the study area within the potential beech forests of the alliance *Aremonio agrimonioidis-Fagion sylvaticae*, at its southern limit and in transition towards those of the southern Apennines endemic alliance *Geranio versicoloris-Fagion sylvaticae*. These old stands are characterised by the high presence of chamaephyte species such as *Polygala chamaebuxus*, a common species of natural pine forests of *Erico-Pinetea* (Biondi et al. 2014) and typical of the Apennine *Pinus mugo* krummholz (Stanisci 1997), which grows on outcropping rock and in thin soils.

Subassociation *amelanchieretosum ovalis* subass. nov. (rels 17–25) is differentiated by phanerophyte and nanophanerophyte pre-forest species, such as *Amelanchier ovalis*, *Cotoneaster tomentosus* and *Viburnum lantana*, and it refers to the more thermophilous aspect of the new association *Orthilio secundae-Pinetum nigrae*. It is found on the rugged slopes of Ovindoli (Velino-Sirente mountain ridge) and Arischia (Gran Sasso mountain group) on soils rich in skeleton.

Finally, subassociation *saniculetosum europaeae* subass. nov. refers to the pioneer coenoses with *Pinus nigra* that has developed at the highest elevation, with a more significant presence of beech forest species. It is found for the Sibillini mountains and in the northern part of the study area (Mount Carpegna), within the potential of the macrothermic beech woods of the sub-alliance *Lathyro veneti-Fagenion sylvaticae* (*Aremonio agrimonioidis-Fagion sylvaticae*).

DIGITALIDI MICRANTHAE–PINETUM NIGRAE ass. nov. Suppl. material, Table S2: rels 1–27; *typus* rel. 16: Mount Predicatore locality, Gola della Rossa e di Frasassi Natural Regional Park, geographic coordinates (33T 335398m E, 4811897m N), Implantation date (1914-1916); Elevation (700 m a.s.l.); Aspect (West); Slope (35°): Area (400 m2); Cover (65%);

Characteristic and differential species of the association *Digitalidi micranthae–Pinetum nigrae*: *Pinus nigra* subsp. *nigra* 3, *Digitalis micrantha* +, *Clematis vitalba* +, *Quercus ilex* +, *Asparagus acutifolius* +, *Lonicera etrusca* 1, Characteristic and differential species of the alliance *Junipero hemisphaericae-Pinion nigrae*, order *Junipero communis-Pinetalia nigrae*, and class *Erico-Pinetea*: *Fraxinus ornus* 1, *Juniperus deltoides* +, *Juniperus communis* (s.l.) +; Species from the class *Querco-Fagetea*: *Viola alba* subsp. *dehnhardtii* +, *Acer campestre* +, *Acer opalus* subsp. *obtusatum* +, *Quercus cerris* +; Other species: *Brachypodium rupestre* 1, *Bromopsis erecta* +, *Dactylis glomerata* +, *Galium corrudifolium* +, *Lotus corniculatus* +, *Fragaria vesca* +, *Hieracium murorum* (s.l.) +, *Rubus ulmifolius* +, *Eryngium amethystinum* +, *Carex flacca* +, *Cotinus coggygria* +, *Pteridium aquilinum* +, *Clinopodium vulgare* +.

The new association *Digitalidi micranthae-Pinetum nigrae* brings together the thermophilous and rupestrian forest communities dominated by *Pinus nigra* subsp. *nigra* of artificial origin that are typically found from the upper mesotemperate to the lower supratemperate thermotypes with the subMediterranean variant. They are present at elevations from 650 m a.s.l. (Mount Catria) to 1270 m a.s.l. (Mount Velino) on the rugged slopes of the limestone reliefs of the central Apennines with predominantly west, east and south exposures, and as part of the potential of the mixed deciduous forests of the alliance *Carpinion orientalis* (mainly suballiance *Cytiso-Quercenion pubescentis*), and to a lesser extent of those of the alliance *Fraxino*

Table 1. Synoptic table of *Pinus nigra* syntaxa belong to the *Junipero communis-Pinetalia nigrae* in Apennines. Abbreviations of associations in column: JUN-PIN: *Junipero hemisphaericae-Pinetum nigrae*; ORT-PIN: *Orthilio secundae-Pinetum nigrae*; DIG-PIN: *Digitalidi micranthae-Pinetum nigrae*; GEN-PIN: *Genisto sericeae-Pinetum nigrae*. Values in the columns are percentage frequencies, phi coefficient value percent is given in brackets for species with Fisher's exact test value < 0.05 (see also Suppl. material, Table S3). Characteristic and differential species of the plant associations originally indicated by authors are in italics.

Vegetation type No. of releves	JUN-PIN 6	ORT-PIN 32	DIG-PIN 27	GEN-PIN 6
Junipero hemisphaericae-Pinetum nigrae Biondi et Allegrezza 2020				
(*typus* of alliance *Junipero hemisphaericae-Pinion nigrae* Biondi et Allegrezza 2020)				
Rosa spinossima	100 (100)			
Cotoneaster pyrenaicus	83 (87)	6		
Oreoherzogia fallax	50 (62)		4	
Daphne oleoides	83 (85)	3		
Arctostaphylos uva-ursi	67 (75)	3		
Brachypodium genuense	100 (100)			
Armeria gracilis subsp. majellensis	50 (65)			
Dianthus longicaulis	100 (98)	3		
Galium lucidum	50 (65)			
Gymnadenia conopsea	50 (65)			
Linaria purpurea	50 (65)			
Trifolium repens	33 (52)			
Verbascum mallophorum	33 (52)			
Veronica chamaedrys	33 (52)			
Helianthemum nummularium subsp. obscurum	33 (45)	6		
Orthilio secundae-Pinetum nigrae ass. nov.				
Orthilia secunda		63 (75)		
Polygala chamaebuxus		38 (55)		
Cephalanthera rubra		25 (44)		
Epipactis helleborine		41 (58)		
Hieracium murorum (s.l.)		53 (52)	19	
Acer pseudoplatanus		47 (48)	19	
Festuca stricta subsp. trachyphylla		22 (41)		
Tanacetum corymbosum subsp. achillae		25 (44)		
Acer monspessulanum		22 (37)	4	
Digitalidi micranthae-Pinetum nigrae ass. nov.				
Clematis vitalba		25	70 (63)	
Hedera helix		6	59 (67)	
Prunus mahaleb		9	44 (52)	
Lonicera xylosteum			41 (58)	
Asparagus acutifolius			33 (52)	
Lonicera etrusca			15	
Emerus majus subsp. emeroides			33 (52)	
Crataegus monogyna		3	30 (45)	
Daphne laureola		6	30 (42)	
Acer campestre		19	63 (61)	
Fragaria vesca			22 (42)	
Inula conyzae			22 (42)	
Rubus caesius			22 (42)	
Rubus hirtus (group)		3	30 (45)	
Viola alba subsp. dehnhardtii		41	70 (55)	
Teucrium chamaedrys		31	27 (55)	
Genisto sericeae-Pinetum nigrae Bonin 1978				
Genista sericea				67 (77)
Onosma echioides			4	83 (89)
Euphorbia barrelieri				50 (65)
Linum tenuifolium		3		83 (87)
Polygala major				67 (77)
Hippocrepis comosa				67 (77)
Plantago maritima subsp. serpentina				67 (77)
Echinops ritro				50 (65)
Teucrium montanum		6		50 (60)
Achnatherum calamagrostis				33 (52)
Carex kitaibeliana				33 (52)
Convolvulus elegantissimus				33 (52)
Helianthemum apenninum				33 (52)
Pinus heldreichii subsp. leucodermis				33 (52)
Viola cassinensis subsp. pseudogracilis				33 (52)
Trinia glauca	17			33 (36)
Helictochloa praetutiana	33			50 (42)
Junipero hemisphaericae-Pinion nigrae Biondi et Allegrezza 2020				
(*typus* association *Junipero hemisphaericae-Pinetum nigrae* Biondi et Allegrezza 2020)				
Digitalis micrantha	50	9	70 (47)	
Cytisus spinescens		72	33	100 (56)
Cytisophyllum sessilifolium		47	19	67 (41)

Table 1. Continuation.

Vegetation type	JUN-PIN	ORT-PIN	DIG-PIN	GEN-PIN
No. of releves	6	32	27	6
Lomelosia crenata s.l.		16		100 (91)
Sesleria nitida		59 (41)	52	
Siler montanum subsp. siculum		38		33
Junipero communis-Pinetalia nigrae Biondi et Allegrezza 2020 (*typus* alliance *Fraxino orni-Pinion nigrae* Em 1978)				
Pinus nigra	100	100	100	100
Juniperus communis s.l.	100 (63)	56	26	
Sesleria junceifolia complex	67	6		100 (66)
Juniperus delthoides		31	44	
Trasgressive species				
Fraxinus ornus	17	81	100 (49)	33
Sorbus aria	100	59	67	100
Ostrya carpinifolia		41	48	83 (46)
Erico-Pinetea Horvat 1959				
Amelanchier ovalis		34	22	33
Carex humilis	33	53 (44)		
Cotoneaster tomentosum		16	4	
Goodyera repens		6	4	
Epipactis atrorubens		6		
Other species				
Fagus sylvatica	33	69 (38)	30	17
Bromopsis erecta	17	41	59	50
Globularia meridionalis	67	34	11	33
Festuca circummediterranea	83 (60)	13	7	33
Euphorbia cyparissias	67 (56)	19	11	
Hypericum perforatum	50 (47)	9	15	
Helianthemum oelandicum subsp. incanum	83		4	100 (62)
Rosa canina s.l.	83 (49)	34	48	
Viburnum lantana	33	19	4	
Carex macrolepis	17	28		33
Brachypodium rupestre		41	78 (54)	17
Galium corrudifolium		16	26	83 (64)
Acer opalus subsp. obtusatum		56	52	33
Pteridium aquilinum		3	7	33
Quercus pubescens s.l.		25	48	50
Quercus ilex		6	41	83 (63)
Laburnum anagyroides		19	26	67 (50)
Poterium sanguisorba subsp. balearicum		3	22	50 (46)

orni-Quercion ilicis. In some cases, such as for the southern slopes of Mount Velino in the inner part of Abruzzo, the *Pinus nigra* stands of the new association represents the actual limit of the forests that are in dynamic contact with preforest communities of *Juniperus communis* subsp. *hemisphaerica* and *J. communis* subsp. *nana*.

The structure of the pine forest is irregular and has an average of 29.5 species per relevé. The dominant tree layer is monospecific as *Pinus nigra*, with an average height of 20 m and mean coverage of 70% to 80%. The shrub layer is well represented; in addition to *Pinus nigra* and *Fraxinus ornus*, it is characterised by lianose species (*Hedera helix*, *Clematis vitalba*, *Lonicera etrusca*), pre-forest species (*Prunus mahaleb*, *Juniperus delthoides*) and some forest species (*Quercus ilex*, *Q. pubescens* s.l.). The herbaceous layer is mainly seen as edge species (*Digitalis micrantha*, *Brachypodium rupestre*) followed by those of grasslands (*Bromopsis erecta*, *Sesleria nitida*). The renewal is given by *Fraxinus ornus* (always present) and *Pinus nigra* (renewal seen for 15 relevés of 27 in total).

The characteristic and differential species of the new association *Digitalidi micranthae-Pinetum nigrae* are considered to be: *Pinus nigra* subsp. *nigra*, *Digitalis micrantha*, *Clematis vitalba*, *Hedera helix*, *Prunus mahaleb*, *Quercus ilex*, *Lonicera xylosteum*, *Asparagus acutifolius* and *Lonicera etrusca*. The new association *Digitalidi micranthae-Pinetum nigrae* is referred to the central-southern Apennines alliance *Junipero hemisphaericae-Pinion nigrae*, order *Junipero communis-Pinetalia nigrae*, of the class *Erico-Pinetea*.

As part of the new association, the *Cephalanthera longifolia* variant (rels 21–27 of Suppl. material 1, Table S2) is also highlighted. This refers to the mesophilous aspect of the association, and it is found predominantly at the northern limit of the study area and mainly on the northern slopes of the reliefs at an average elevation of 900 m a.s.l.

Comparison with the *Pinus nigra* subsp. *nigra* natural forests of the central-southern Apennines and syntaxonomic considerations

For the *Pinus nigra* s.l. forests of the central southern Apennine-Balkan mountain ranges, the order *Junipero communis-Pinetalia nigrae* (*typus* alliance *Fraxino orni-Pinion nigrae* Em 1978) was recently proposed as vicar-

iant of the order *Erico-Pinetalia*. These pine communities lie within the temperate macroclimate of the subMediterranean variant. In addition to species with Mediterranean and Mediterranean mountain distribution areas, they are characterised by a strong endemic component. This order includes the alliance *Junipero hemisphaericae-Pinion nigra*e that brings the pine forests together with *Pinus nigra* subsp. *nigra* of the central-southern limestone Apennines, which extends from the Sibillini group down to the Pollino group, mostly of the supratemperate thermotype. However, there are only two associations that are actually described for the natural *P. nigra* forests in the Apennines: *Junipero hemisphaericae-Pinetum nigrae* (*typus* Apennines alliance *Junipero hemisphaericae-Pinion nigra*e) for the upper supratemperate thermotype of Gran Sasso d'Italia and in dynamic contact with the juniper from the class *Loiseleurio procumbentis-Vaccinietea* (Biondi & Allegrezza 2020), and *Genisto sericeae-Pinetum nigra*e for the Pollino mountains (Bonin 1978), with a clearly Mediterranean influence and in contact with holm oaks and *Genista sericea* garrigue (Allegrezza, Tesei, Ottaviani; from unpublished relevés in the same area that are not presented in the present study). To highlight any similarities and differences between the artificial pine forests described in this study and the natural ones described for the Apennines, a comparison was made using the synthetic columns of the relevés (Table 1). The comparison (Table 1, synoptic table) shows the floristic autonomy of the two new associations described in this study within the biogeographic context of the alliance *Junipero hemisphaericae-Pinion nigra*e. In addition, this highlights the presence of many heliophilous and thermophilous species (e.g., *Cytisophyllum sessilifolium*) at the highest elevations (association *Orthilio secundae-Pinetum nigra*e) that are usually distributed at lower elevations, as demonstrated by Allegrezza et al. (2020). Based on the results obtained, to extend the bioclimatic significance and the plant landscape context of the Apennines alliance *Junipero hemisphaericae-Pinion nigrae* to include also the Apennines subMediterranean *Pinus nigra* coenoses, it is considered appropriate to add in the combination of the specific characteristics the following species: *Cytisus spinescens*, *Cytisophyllum sessilifolium*, *Sesleria nitida* and *Lomelosia crenata* s.l.

Conclusions

This study represents the first syntaxonomic analysis of the *Pinus nigra* subsp. *nigra* artificial stands in the Apennines. Specifically, it refers exclusively to the mature *Pinus nigra* forest plantations in the central Apennines at elevations above 600 m a.s.l. that were planted before the 1950s and have not been managed for many years. Two new plant associations are described here: *Orthilio secundae-Pinetum nigra*e and *Digitalidi micranthae-Pinetum nigrae* belonging to the alliance *Junipero hemisphaericae-Pinion nigra*e of the central-southern Apennines. The association *Orthilio secundae-Pinetum nigra*e brings together the relative mesophilous mature pine forests of the supratemperate thermotype in the plant landscape context of the alliance *Aremonio agrimonioidis-Fagion sylvaticae*; *Digitalidi micranthae-Pinetum nigrae* is referred to the thermophilous and rupestrian mature pine forests present typically for the mesotemperate thermotype, but also for the low supratemperate thermotype with the subMediterranean variant in the plant landscape context of the alliance *Carpinion orientalis* (mainly *Cytiso-Quercenion pubescentis*). The comparison of the two new associations described with the literature phytosociological data for *Pinus nigra* natural communities in the Apennines highlights the floristic autonomy of these coenoses within the biogeographic context of the alliance *Junipero hemisphaericae-Pinion nigrae*. These *Pinus nigra* artificial communities represent a reference floristic model to deepen the ecology and floristic composition of the new *Pinus nigra* subsp. *nigra* natural communities, due to the pine colonisation of the abandoned grasslands by seed from pine plantations. This is a common phenomenon in the Apennines (e.g., Piermattei et al. 2014), as a consequence of the actual time of climate change and abandonment of the marginal mountain areas.

Syntaxonomic scheme

ERICO-PINETEA Horvat 1959
JUNIPERO COMMUNIS-PINETALIA NIGRAE Biondi et Allegrezza 2020
Junipero hemisphaericae-Pinion nigrae Biondi et Allegrezza 2020
Orthilio secundae-Pinetum nigrae ass. nov.
subass. *typicum*
saniculetosum europaeae subass. nov.
amelanchieretosum ovalis subass. nov.
Digitalidi micranthae-Pinetum nigrae ass. nov.

Other syntaxa quoted in the text

Aremonio agrimonioidis-Fagion sylvaticae (Horvat 1938) Torok, Podani & Borhidi 1989; Carpinion orientalis Horvat 1958; *Cytiso-Quercenion pubescentis* Ubaldi 1995; *Junipero-Pinetea sylvestris* Rivas-Martınez 1965 nom. inv. propos. Mucina et al. 2016; *Erico-Pinetalia* Horvat 1959 nom. inv. propos. Mucina et al. 2016; *Erico carneae-Pinion* Br.-Bl. in Br.-Bl. et al. 1939 nom. invers. propos. Mucina et al. 2016; *Erico-Fraxinion orni* Horvat 1959 nom. inv. prop. Mucina et al. 2016; *Epipactido muelleri-Pinion sylvestris* J.-M. Royer in J.-M. Royer, Felzines, Misset & Thévenin 2006; *Quercetalia pubescentis-petraeae* Klika 1933; *Fagetalia sylvaticae* Pawłowski in Pawłowski, Sokołowski & Wallisch 1928; *Berberidion vulgaris* Br.-Bl. 1950; *Phleo ambigui-Bromion erecti* Biondi, Ballelli, Allegrezza & Zuccarello ex Biondi & Galdenzi 2012; *Cytiso spinescentis-Satureion montanae* Pirone & Tammaro 1997; *Cerastio tomentosi-Globularion meridionalis* Ciaschetti, Pirone, Giancola, Frattaroli & Stanisci 2016; *Daphno oleoidis-Ju-*

niperion alpinae Stanisci 1997; *Loiseleurio procumbentis-Vaccinietea* Eggler ex Schubert 1960; *Geranio versicoloris-Fagion sylvaticae* Gentile 1970; *Lathyro veneti-Fagenion sylvaticae* Zitti, Casavecchia, Pesaresi, Taffetani & Biondi 2014; *Genisto sericeae-Pinetum nigrae* Bonin 1978.

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Appendixes

Appendix I – Sporadic species

Table S1 - Rel. 1: *Crataegus monogyna* Jacq. +; rel. 2: *Helleborus foetidus* L. +; rel. 3: *Hepatica nobilis* Schreb. 1. *Neottia ovata* 1; rel. 4: *Pimpinella tragium* Vill. +, *Hippocrepis glauca* +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Thymus striatus* subsp. *acicularis* +, *Drymochloa sylvatica* 1, *Plantago lanceolata* L. +, *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace +; rel. 5: *Pimpinella tragium* Vill. +, *Lotus corniculatus* L. +, *Centaurea ceratophylla* Ten. 1, *Hippocrepis glauca* Ten. +, *Pilosella officinarum* Vaill. 1; *Thymus striatus* subsp. *acicularis* 1, *Anthericum liliago* L. +; *Koeleria splendens* Presl +; *Dianthus longicaulis* +, *Leontodon crispus* Vill. 1, *Linum tenuifolium* 1; rel. 6: *Pimpinella tragium* Vill. 1, *Prunus mahaleb* L. +, *Centaurea ceratophylla* 1, *Drymochloa sylvatica* 1, *Ononis pusilla* L. +; rel. 7: *Laburnum anagyroides* Medik. +, *Limodorum abortivum* (L.) Sw. +, *Viola reichenbachiana* Jord. ex Boreau +, *Viola reichenbachiana* Jord. ex Boreau +, *Peucedanum verticillare* (L.) Mert. et W.D.J. Koch +; rel. 8: P*runus mahaleb* L. +, *Festuca circummediterranea* Patzke +, *Viola riviniana* Rchb. +, *Hedera helix* L. +, *Asplenium adiantum-nigrum* L. +; rel. 9: *Laburnum anagyroides* Medik. +, *Dactylis glomerata* L. +, *Festuca circummediterranea* Patzke +, *Pilosella officinarum* Vaill. +, *Hedera helix* L. +, *Anthericum liliago* L. +, *Carlina vulgaris* L. +, *Helleborus foetidus* L. +, *Koeleria splendens* Presl +, *Teucrium montanum* L. +, *Anthyllis vulneraria* L. (s.l.) +, *Carlina acaulis* L. subsp. *caulescens* (Lam.) Schübl. & G. Martens +, *Centaurea rupestris* L. +, *Scabiosa columbaria* L. (s.l.) +, *Pimpinella saxifraga* L. +; rel. 10: *Laburnum anagyroides* Medik. +, *Viola reichenbachiana* Jord. ex Boreau 2, *Festuca circummediterranea* Patzke +, *Pilosella officinarum* Vaill. +, *Pimpinella saxifraga* L. +, *Arabis hirsuta* (L.) Scop. +, *Pyrus communis* L. subsp. *pyraster* (L.) Ehrh. +, *Hieracium villosum* Jacq. (group) +, *Viola eugeniae* Parl. +; rel. 11: *Pimpinella tragium* Vill. +, *Limodorum abortivum* (L.) Sw. +, *Emerus majus* Mill. +, *Teucrium montanum* L. +, *Seseli tommasinii* +; rel. 12: *Laburnum anagyroides* Medik. 1, *Lotus corniculatus* L. +, *Centaurea ceratophylla* +, *Hippocrepis glauca* +, *Thymus striatus* subsp. *acicularis* +; rel. 13: *Emerus majus* Mill. 1, *Epipactis microphylla* +, *Arabis* sp. +; rel. 14: *Hippocrepis glauca* +, *Emerus majus* Mill. +, *Silene italica* (L.) Pers. +; rel. 15: *Lotus corniculatus* L. +, *Prunus mahaleb* L. +, *Centaurea ceratophylla* +, *Festuca circummediterranea* Patzke +, *Limodorum abortivum* (L.) Sw. +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Cotoneaster pyrenaicus* +, *Polygala nicaeensis* +; rel. 16: *Pimpinella tragium* Vill. +, *Lotus corniculatus* L. 1, *Cerastium tomentosum* +; rel. 17: *Galium corrudifolium* Vill. +, *Hepatica nobilis* Schreb. +, *Pimpinella tragium* Vill. +, *Prunus mahaleb* L. +, *Corylus avellana* L. 2, *Pilosella officinarum* Vaill. +, *Viola riviniana* Rchb. +, *Daphne oleoides* Schreb. +; rel. 18: *Galium corrudifolium* Vill. +, *Arabis turrita* L. +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Quercus ilex* L. +, *Daphne oleoides* Schreb. +, *Helianthemum nummularium* (L.) Mill. subsp. *obscurum* (Celak.) Holub +, *Arctostaphylos uva-ursi* (L.) Spreng. +, *Gentiana dinarica* Beck +, *Sorbus aucuparia* L. +, *Thymus serpyllum* (s.l.) +; rel. 19: *Galium corrudifolium* Vill. +, ***Laburnum anagyroides*** Medik. +, *Cephalanthera damasonium* (Mill.) Druce +, *Knautia calycina* +, *Limodorum abortivum* (L.) Sw. +, *Primula vulgaris* Huds.+, *Hypericum perforatum* L. +, *Quercus ilex* L. +, *Campanula micrantha* Bertol. +, *Epipactis muelleri* Godfery +, *Peucedanum oreoselinum* (L.) Moench +, *Pyrus communis* L. subsp. *pyraster* (L.) Ehrh. +, *Leontodon hispidus* L. (s.l.) +, *Luzula sylvatica* (Huds.) Gaudin +, *Potentilla rigoana* Th. Wolf +, *Poterium sanguisorba* L. subsp. *balearicum (Bourg. ex Nyman) Stace* +, *Senecio inaequidens* DC. +, *Silene ciliata* Pourr. subsp. *graefferi* (Guss.) Nyman +, *Silene vulgaris* (Moench) Garcke subsp. *tenoreana* (Colla) Soldano & F. Conti +; rel. 20: *Cephalanthera damasonium* (Mill.) Druce +, *Dactylis glomerata* L. +, *Knautia calycina* +, *Hypericum perforatum* L. +, *Cotoneaster pyrenaicus* +, *Hieracium racemosum* Waldst. & Kit. ex Willd. (s.l.) +, *Vicia cracca* L. +, *Leucanthemum heterophyllum* (Willd.) DC. +, *Prunella laciniata* (L.) L. +, *Sorbus domestica* L. +; rel. 21: *Hepatica nobilis* L., +, *Dactylis glomerata* L. +, *Knautia calycina* +, *Hypericum perforatum* L. +, *Pimpinella saxifraga* L. +, *Carlina vulgaris* L. +, *Pilosella piloselloides* (Vill.) Soják +, *Rosa arvensis* Huds. +, *Acer platanoides* L. +, *Fraxinus excelsior* L. 1, *Globularia bisnagarica* L. +, *Salvia pratensis* L. 1; rel. 22: *Knautia calycina* +, *Luzula sylvatica* (Huds.) Gaudin subsp. *sieberi* (Tausch) K. Richt. +, *Prunus avium* L. +, *Helianthemum nummularium* (L.) Mill. subsp. *obscurum* (Celak.) Holub +, *Sesleria juncifolia* Wulfen ex Suffren +, *Hieracium* sp. +; rel. 23: *Viola reichenbachiana* Jord. ex Boreau +, Viola *riviniana* Rchb. +, *Luzula sylvatica* (Huds.) *Gaudin* subsp. *sieberi* (Tausch) K. Richt. +, Prunus avium L. +, *Arabis hirsuta* (L.) Scop. +, *Rosa arvensis* Huds. +, *Sesleria juncifolia* Wulfen ex Suffren +, Campanula scheuchzeri Vill. +, *Galium verum* L. +, *Hieracium pseudogrovesianum* Gottschl. 1, *Lilium bulbiferum* L. subsp. *croceum* (Chaix) Jan +, *Monotropa hypopitys* L. +, *Rhamnus saxatilis* Jacq. +; rel. 24: *Galium corrudifolium* Vill. +, *Viola reichenbachiana* Jord. ex Boreau +, *Dactylis glomerata* L. +, *Primula vulgaris* Huds. +, *Viola riviniana* Rchb. +, *Luzula sylvatica* (Huds.) Gaudin subsp. *sieberi* (Tausch) K. Richt. 1, *Epipactis muelleri* Godfery +, *Hieracium racemosum* Waldst. & Kit. ex Willd. (s.l.) +, *Vicia cracca* L. +, *Bupleurum falcatum* L. subsp. *cernuum* (Ten.) Arcang. +; rel. 25: *Lotus corniculatus* L. +, *Digitalis micrantha* Roth ex Schweigg. +, *Pilosella piloselloides* (Vill.) Soják +, *Festuca heterophylla* Lam. +, *Medicago lupulina* L. +; rel. 26: *Galium corrudifo-*

lium Vill. +, *Cephalanthera damasonium* (Mill.) Druce +, *Digitalis micrantha* Roth ex Schweigg.+, *Vicia dasycarpa* Ten. +, *Cirsium morisianum* Rchb. +, *Cnidium silaifolium* (Jacq.) Simonk. +, *Dactylorhiza maculata* L. (s.l.) +, *Heracleum sphondylium* L. subsp. *pyrenaicum* (Lam.) Bonnier & Layens +, *Myosotis sylvatica* Hoffm. +, *Picris hieracioides* L. (s.l.) +, *Platanthera bifolia* (L.) Rchb. +, *Trifolium ochroleucum* Huds. +; rel. 27: *Galium corrudifolium* Vill. +, *Cephalanthera damasonium* (Mill.) Druce +, *Digitalis micrantha* Roth ex Schweigg. +, *Arabis turrita* L. +, *Silene italica* (L.) Pers. +, *Vicia dasycarpa* Ten. +, *Clinopodium alpinum* (L.) Merino +, *Galium mollugo* L. subsp. *erectum* Syme +, *Hieracium cymosum* L. +, *Poa nemoralis* L. +, *Trifolium alpestre* L. +, *Trifolium pratense* L. +; rel. 28: *Hepatica nobilis* Schreb. +, *Viola reichenbachiana* Jord. ex Boreau 1, *Primula vulgaris* Huds. 1, *Prunus avium* L. +, *Abies alba* Mill. +, *Campanula micrantha* Bertol. +, *Daphne laureola* L. +, *Cardamine bulbifera* (L.) Crantz +, *Prunella vulgaris* L. +, *Taxus baccata* L. +; rel. 29: *Viola reichenbachiana* Jord. ex Boreau +, *Corylus avellana* L. +, *Abies alba* Mill. +, *Melittis melissophyllum* L. +, *Pteridium aquilinum* (L.) Kuhn +, *Rubus hirtus* (group) +; rel. 30: *Hepatica nobilis* Schreb. +, *Corylus avellana* L. +, *Peucedanum oreoselinum* (L.) Moench +, *Fraxinus angustifolia* Vahl subsp. *oxycarpa* (Willd.) Franco & Rocha Afonso +, *Lilium martagon* L. +, *Populus tremula* L. +, *Trifolium montanum* L. subsp. *rupestre* (Ten.) Nyman +; rel. 31: *Laburnum anagyroides* Medik. +, *Corylus avellana* L. +, *Arabis turrita* L. +, *Melittis melissophyllum* L. +; rel. 32: *Primula vulgaris* Huds. +, *Silene italica* (L.) Pers. +, *Daphne laureola* L. +, *Equisetum arvense* L. +, *Galium aparine* L. +, *Lathyrus pratensis* L. +, *Orchis purpurea* Huds. +, *Stellaria media* (L.) Vill. +, *Veronica hederifolia* L.+.

Table S2 - Rel. 1: *Scabiosa columbaria* L. (s.l.) +, *Sorbus domestica* L. +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Globularia meridionalis* (Podp.) O. Schwarz +, *Festuca circummediterranea* Patzke +, *Arabis hirsuta* (L.) Scop. +, *Ononis pusilla* L. +, *Ajuga reptans* L. +, *Asperula aristata* L. f. subsp. *oreophila* (Briq.) Hayek +, *Asperula cynanchica* L.+, *Pilosella piloselloides* (Vill.) Soják +, *Hieracium* sp. +, *Juglans regia* L. +, *Leontodon crispus* Vill. +, *Pimpinella tragium* Vill. +, *Prunella laciniata* (L.) L. +, *Saxifraga paniculata* Mill. +, *Thymus longicaulis* C. Presl +: rel. 2: *Rubus caesius* L. +, *Inula conyzae* (Griess.) Meikle +, *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace +, *Hieracium murorum* L. (s.l.) +, *Eryngium amethystinum* L. +, *Festuca heterophylla* Lam. +, *Hypericum perforatum* L. +, *Solidago virgaurea* L. +, *Campanula glomerata* L. 1, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Leontodon hispidus* L. (s.l.) +, *Clinopodium alpinum* (L.) Merino +, *Carex digitata* L. +, *Coronilla minima* L. +, *Trifolium ochroleucum* Huds. +, *Bellis perennis* L. +, *Carex flacca* Schreb. +, *Crepis leontodontoides* All. +, *Goodyera repens* (L.) R. Br. +, *Onosma echioides* (L.) L. +, *Picea abies* (L.) H. Karst. +, *Silene vulgaris* (Moench) Garcke subsp. *tenoreana* (Colla) Soldano & F. Conti +; rel. 3: *Listera ovata* (L.) R. Br. +, *Rubus caesius* L. +, *Inula conyzae* (Griess.) Meikle +, *Poterium sanguisorba* subsp. *balearicum* (Bourg. ex Nyman) Stace +, *Scabiosa columbaria* L. (s.l.) +, *Hieracium murorum* L. (s.l.) +, *Eryngium amethystinum* L. +, *Festuca heterophylla* Lam. +, *Hypericum perforatum* L. +, *Solidago virgaurea* L. +, *Abies alba* Mill. +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Globularia bisnagarica* L. +, *Leontodon hispidus* L. (s.l.) +, *Robinia pseudoacacia* L. +, *Clinopodium alpinum* (L.) Merino +, *Carlina utzka* Hacq. +, *Geranium lucidum* L. +, *Genista tinctoria* L. +, *Stachys recta* L. (s.l.) +; rel. 4: *Listera ovata* (L.) R. Br. +, *Fragaria vesca* L. +, *Inula conyzae* (Griess.) Meikle +, *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace +, *Scabiosa columbaria* L. (s.l.) +, *Acer pseudoplatanus* L. +, *Hieracium murorum* L. (s.l.) 1, Eryngium amethystinum L. +, *Festuca heterophylla* Lam. +, *Pilosella officinarum* Vaill. +, *Globularia bisnagarica* L. +, *Leontodon hispidus* L. (s.l.) +, *Robinia pseudoacacia* L. +, *Carex digitata* L. +, *Coronilla minima* L. +, *Ononis pusilla* L. +, *Trifolium ochroleucum* Huds. +, *Achillea millefolium* L. +, *Crepis lacera* Ten. +; rel. 5: *Cephalanthera damasonium* (Mill.) Druce +, *Arabis turrita* L. +, *Inula conyzae* (Griess.) Meikle +, *Scabiosa columbaria* L. (s.l.) +, *Festuca heterophylla* Lam. 1, *Senecio inaequidens* DC. +, *Silene italica* (L.) Pers. subsp. *italica* +, *Carex halleriana* Asso +, *Festuca inops* De Not. +, *Limodorum abortivum* (L.) Sw. +; rel. 6: *Inula conyzae* (Griess.) Meikle +, *Scabiosa columbaria* L. (s.l.) +, *Pilosella officinarum* Vaill. +, *Senecio inaequidens* DC. +, *Silene italica* (L.) Pers. +, *Abies cephalonica* Loud. +, *Globularia meridionalis* (Podp.) O. Schwarz +, *Cedrus deodara* (D. Don) G. Don. +, *Festuca circummediterranea* Patzke +, *Arabis collina* Ten. +, *Astragalus aquilanus* Anzal. +, *Carex divulsa* Stokes +, *Erysimum pseudorhaeticum* Polatschek +, *Picris hieracioides* L. (s.l.) +, *Pimpinella major* (L.) Huds. +; rel. 7: *Rubus ulmifolius* Schott +, *Hypericum perforatum* L. +, *Pilosella officinarum* Vaill. +, *Senecio inaequidens* DC. +, *Silene italica* (L.) Pers. +, *Abies cephalonica* Loud. +, *Globularia meridionalis* (Podp.) O. Schwarz +, *Cedrus deodara* (D. Don) G. Don. +, *Ferula communis* L. +, *Helianthemum oelandicum* (L.) Dum. Cours. subsp. *incanum* (Willk.) G. López +, *Hieracium grovesianum* Arv.-Touv. ex Belli (s.l.) +, *Knautia calycina* +, *Pimpinella saxifraga* L. +; rel. 8: *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace +, *Sorbus domestica* L. +, *Campanula glomerata* L. +, *Rosa arvensis* Huds. +, *Securigera varia* (L.) Lassen +; rel. 9: *Sorbus domestica* L. 1, *Lonicera caprifolium* L. +, *Cyanus triumfetti* (All.) Dostál ex Á. & D. Löve +, *Arabis hirsuta* (L.) Scop. +, *Crataegus laevigata* (Poir.) DC. 1, *Emerus majus* Mill. +; rel. 10: *Corylus avellana* L. 1, *Arabis turrita* L. +, *Fragaria vesca* L. +, *Inula conyzae* (Griess.) Meikle +, *Campanula trachelium* L. +, *Cornus sanguinea* L. (s.l.) +, *Viola reichenbachiana* Jord. ex Boreau +, *Euphorbia cyparissias* L. +, *Robinia pseudoacacia* L. +, *Euonymus latifolius* (L.) Mill. +, *Saponaria ocymoides* L. +, *Alyssoides utriculata* (L.) Medik. +, *Doronicum columnae* Ten. +, *Poa nemoralis* L. +, *Rhamnus saxatilis* Jacq. +, *Thalictrum aquilegiifolium* L. +; rel. 11: *Corylus avellana* L. +, *Arabis turrita* L. +, *Rubus ulmifolius* Schott +, *Cornus sanguinea* L. (s.l.) +, *Hypericum perforatum* L. +, *Viola reichenbachiana* Jord. ex Boreau +, *Euphorbia cyparissias* L.

+, *Tamus communis* L. +, *Berberis vulgaris* L. +, *Euonymus latifolius* (L.) Mill. +, *Medicago lupulina* L. +, *Saponaria ocymoides* L. +, *Acer monspessulanum* L. +, *Cirsium erisithales* (Jacq.) Scop. +, *Potentilla micrantha* Ramond ex DC. +, *Oreoherzogia fallax* +, *Rhamnus cathartica* L. +; rel. 12: *Corylus avellana* L. *Campanula trachelium* L. +, *Lonicera caprifolium* L. +, *Prunus avium* L. +, *Vicia cracca* L. +, *Berberis vulgaris* L. +, *Pinus sylvestris* L. 1, *Sonchus oleraceus* L. +, *Melittis melissophyllum* L. +; rel. 13: *Corylus avellana* L. +, *Arabis turrita* L. +, *Hieracium murorum* L. (s.l.) +, *Campanula trachelium* L. +, *Senecio inaequidens* DC. +, *Viola reichenbachiana* Jord. ex Boreau +, *Vicia cracca* L. +, *Pinus sylvestris* L. +, *Sonchus oleraceus* L. +, *Geranium lucidum* L. +, *Lathyrus apacha* L. +, *Sedum rupestre* L. +; rel. 14: *Cephalanthera damasonium* (Mill.) Druce +, *Scabiosa columbaria* L. (s.l.) +, *Cornus mas* L. +, *Pilosella officinarum* Vaill. +, *Clematis recta* +, *Osyris alba* L. 2, *Vincetoxicum hirundinaria* Medik. +; rel. 15: *Cornus mas* L. +, *Aremonia agrimonoides* (L.) DC. +, *Clematis recta* +; rel. 16: *Fragaria vesca* L. +, *Hieracium murorum* L. (s.l.) +, *Rubus ulmifolius* Schott +, *Eryngium amethystinum* L. +, *Carex flacca* Schreb. +, *Cotinus coggygria* Scop. +, *Pteridium aquilinum* (L.) Kuhn +, *Clinopodium vulgare* L. +; rel. 17: *Cephalanthera damasonium* (Mill.) Druce +, *Fragaria vesca* L. +, *Rubus ulmifolius* Schott 1, *Sorbus domestica* L. +, *Cotinus coggygria* Scop. +, *Buglossoides purpurocaerulea* (L.) I.M. Johnst. +; rel. 18: *Aremonia agrimonoides* (L.) DC. +, *Viburnum lantana* L. +; rel. 19: *Cornus sanguinea* L. (s.l.) 1, *Rosa arvensis* Huds. +, *Euonymus europaeus* L. +; rel. 20: *Campanula trachelium* L. +, *Cornus sanguinea* L. (s.l.) +, *Tamus communis* L. +, *Medicago lupulina* L. +; rel. 21: *Listera ovata* (L.) R. Br. +, +, *Acer pseudoplatanus* L. 1, *Lonicera caprifolium* L. 1, *Abies alba* Mill. +, *Lathyrus sylvestris* L. +, *Orchis purpurea* Huds. +, *Tamus communis* L. +, *Carex flacca* Schreb. +, *Galium mollugo* L. subsp. *erectum* Syme +, *Peucedanum verticillare* (L.) Mert. et W.D.J. Koch 1; rel. 22: *Listera ovata* (L.) R. Br. +, *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace +, *Sorbus domestica* L. +, *Lonicera caprifolium* L. +, *Prunus avium* L. +, *Orchis purpurea* Huds. +, *Vicia cracca* L. +, *Peucedanum verticillare* (L.) Mert. et W.D.J. Koch 1, *Cruciata glabra* (L.) Ehrend. +, *Dactylorhiza maculata* L. (s.l.) +; rel. 23: *Cephalanthera damasonium* (Mill.) Druce +, *Arabis turrita* L. +, *Cornus mas* L. +, *Rubus ulmifolius* Schott +, *Lactuca muralis* (L.) Gaertn. +, *Prunus avium* L. +, *Abies cephalonica* Loud. +, *Galium odoratum* (L.) Scop. +, *Helleborus bocconei* Ten. +, *Luzula forsteri* (Sm.) DC. 1, *Luzula sylvatica* (Huds.) Gaudin +, *Ruscus aculeatus* L. +; rel. 24: *Cephalanthera damasonium* (Mill.) Druce +, *Listera ovata* (L.) R. Br. +, *Rubus caesius* L. +, *Acer pseudoplatanus* L. +, *Solidago virgaurea* L. +, *Campanula glomerata* L. +, *Globularia bisnagarica* L. +, *Lathyrus sylvestris* L. +, *Hieracium racemosum* Waldst. & Kit. ex Willd. (s.l.) +, *Lilium bulbiferum* L. subsp. *croceum* (Chaix) Jan +; rel. 25: *Listera ovata* (L.) R. Br. +, *Rubus caesius* L. +, *Cornus mas* L. +, *Lactuca muralis* (L.) Gaertn. +, *Solidago virgaurea* L. +, *Lathyrus sylvestris* L. +, *Orchis purpurea* Huds. +, *Mercurialis annua* L. +, *Sonchus asper* (L.) Hill (s.l.) +, *Stachys officinalis* (L.) Trevis. +; rel. 26: *Corylus avellana* L. +, *Rubus caesius* L. 2, *Fragaria vesca* L. +, *Acer pseudoplatanus* L. +, *Cornus mas* L. 2, *Lactuca muralis* (L.) Gaertn. 2, *Prunus avium* L. +, *Viola reichenbachiana* Jord. ex Boreau +, *Aremonia agrimonoides* (L.) DC. +, *Castanea sativa* Mill. +, *Hepatica nobilis* Schreb. 1, *Mercurialis perennis* L. 1, *Salvia glutinosa* L +, *Viola hirta* L. +; rel. 27: *Cephalanthera damasonium* (Mill.) Druce +, *Corylus avellana* L. +, *Rubus caesius* L. +, *Arabis turrita* L. +, *Fragaria vesca* L. +, *Acer pseudoplatanus* L. +, *Lactuca muralis* (L.) Gaertn. 1, *Silene italica* (L.) Pers. +, *Abies alba* Mill. +, *Rosa arvensis* Huds. +, *Galium mollugo* L. subsp. *erectum* Syme +, *Hieracium racemosum* Waldst. & Kit. ex Willd. (s.l.) +, *Pteridium aquilinum* (L.) Kuhn +, *Ceterach officinarum* Willd. (s.l.) +, *Geranium robertianum* L. +, *Hieracium bifidum* Kit. ex Hornem. (s.l.) +, *Ligustrum vulgare* L. +, *Pyrus communis* L. subsp. *pyraster* (L.) Ehrh. +, *Smirnyum olusatrum* +, *Sorbus aucuparia* L. +.

Appendix II - Relevès dates, localities and geographical coordinates (WGS84–UTM T33)

Table S1 - Rels 1–6: 14/07/1987, Godi Mountain, Abruzzo, Lazio and Molise National Park; Rel. 7: 22/08/2016, near Villetta Barrea (AQ), Abruzzo, Lazio and Molise National Park 33T 411228m E 4625974m N; Rel. 8: 22/08/2016, near Villetta Barrea (AQ), Abruzzo, Lazio and Molise National Park, 33T 410310m E 4625680m N; Rel.: 9: 22/08/2016, near Villetta Barrea (AQ), Abruzzo, Lazio and Molise National Park, 33T 411346m E 4625577m N; Rel. 10: from Allegrezza et al. 2020 Table S1, near Villetta Barrea (AQ) Abruzzo, Lazio and Molise National Park, 33T 411342m E 4625876m N.; rels 11–16: 14/07/1987, Godi Mountain, Abruzzo, Lazio and Molise National Park; Rel. 17: 18/07/2014, Ovindoli (AQ) Sirente-Velino Natural Regional Park, 33T 377221m E 4664977m N; Rel. 18: 31/07/2013, MT. Vettore (AP) Sibillini National Park, 33T 360468m E 4741726m N; Rel 19: 22/08/2014, near Arischia (AQ) Gran Sasso e Monti della Laga National Park, 33T 363711m E 4699142m N; Rel 20: 22/08/2014, near Arischia (AQ) Gran Sasso e Monti della Laga National Park, 33T 363703 m E 4699838 m N; Rel. 21: 22/08/2014, near Arischia (AQ) Gran Sasso e Monti della Laga National Park, 33T 363875m E 4699852m N; Rel. 22: 3/06/2014, near Arischia (AQ) Gran Sasso e Monti della Laga National Park, 33T 363685m E 4699977.01 m N; Rel. 23: from Allegrezza et al. 2020 Table S1, near Arischia(AQ), Gran Sasso e Monti della Laga National Park, 33T 363602m E 4699917m N; Rel. 24: from Allegrezza et al. 2020 Table S1, near Arischia (AQ) Gran Sasso e Monti della Laga National Park, 33T 364148 m E 4699620 m N; Rel. 25: from Allegrezza et al. 2020 Table S1, Mt. Bove (Mc) Sibillini National Park, 33T 351231m E 4752040m N; Rel. 26: from Allegrezza et al. 2020 Table S1, Mt. Bove (Mc) Sibillini National Park, 33T 351158m E 4752467m N; Rel. 27: 22/06/2015, Mt. Bove (Mc) Sibillini National Park, 33T 351318m E 4751931m N; Rel. 28: from Allegrezza et al., 2013 Tab. 3 ril. 3, Mt. Vettore (AP) Sibillini

National Park, 33T 361039m E 4741695m N); Rel. 29: from Allegrezza et al., 2013 Tab. 3 rel. 5, Mt. Vettore (AP) Sibillini National Park, 33T 360766m E 4741808m N; Ril. 30: from Allegrezza et al., 2013 Tab. 3 rel. 4, Mt. Vettore (AP) Sibillini National Park, 33T 360546m E 4741764m N; Rel. 31: from Allegrezza et al., 2013 Tab. 3 rel. 6, Mt. Vettore (AP) Sibillini National Park, 33T 359391m E 4740695m N; Rel. 32: from Allegrezza et al. 2020 Table S1, Mt. Carpegna (PU) Sasso Simone e Simoncello Natural Regional Park, 33T 285336m E 4852663m N.

Table S2 - Rel. 1: 27/07/2015, Assergi (AQ), Gran Sasso e Monti della Laga National Park, 33T 376782m E 4695117m N.; rel. 2: from Allegrezza et al. 2020 Tab. S1 rel. 24, Mt. Acuto (PU) Monte Catria Group, 33T311405m E 4814802m N.; rel. 3: 08/06/2015, Mt. Acuto (PU), Monte Catria Group, 33T 311363m E 4814647m N.; rel. 4: 08/06/2015, Mt. Acuto (PU), Monte Catria Group, 33T 311399m E 4814640m N.; rel. 5: 27/07/2015, Assergi (AQ), Gran Sasso e Monti della Laga National Park, 33T 376737m E 4695357m N.; rel. 6: 04/11/2015, Roio (AQ), Gran Sasso e Monti della Laga National Park, 33T 366580m E 4688403m N.; rel. 7: from Allegrezza et al. 2020 Tab. S1 rel. 23, Roio (AQ), Gran Sasso e Monti della Laga National Park, 33T 366523m E 4688607m N.; rel. 8: 23/08/2014, Mt. Faito (AQ), Sirente-Velino Natural Regional Park, 33T 377738m E 4663951m N.; Ril. 9:23/08/2014, Mt. Faito (AQ), Sirente-Velino Natural Regional Park, 33T 377775m E 4663816m N; rel. 10: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370567m E 4664669m N.; rel. 11: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370290m E 4664692m N.; rel. 12: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370825m E 4664516m N.; Rel 13: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370827mE 4664462m N.; rel. 14: from Allegrezza et al. 2020 Tab. S1 rel. 27, Lama dei Peligni (Ch) Majella National Park, 33T 432997m E 4656548m N.; Rel. 15: 2/08/2016, Lama dei Peligni (Ch), Majella National Park, 33T 432868m E 4656682m N.; rel. 16: from Ottaviani et al. 2015 Tab. 1 rel. 5, Mt. Predicatore (An), Gola della Rossa e di Frasassi Natural Regional Park, 33T 335398m E 4811897m N; Rel. 17: from Ottaviani et al. 2015 Tab. 1 rel. 7, Mt. Predicatore (An), Gola della Rossa e di Frasassi Natural Regional Park, 33T 335316m E 4811778m N.; rel. 18: 27/07/2015, Assergi (AQ), Gran Sasso e Monti della Laga National Park,, 33T 374450m E 4698849m N. Ril. 19: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370587m E 4664630m N.; rel. 20: 17/07/2014, Mt. Velino (AQ), Sirente-Velino Natural Regional Park, 33T 370567m E 4664669m N.; rel. 21: 12/05/2016, Mt. Carpegna (PU), Sasso Simone e Simoncello Natural regional Park, 33T 285866m E 4852744m N. Ril. 22: 12/05/2016, Mt. Carpegna (PU), Sasso Simone e Simoncello Natural regional Park, 33T 285740m E 4852565m N; rel. 23: from Ottaviani et al. 2015 Tab. 1 rel. 24, Mt. Tegolaro (An), Gola della Rossa e di Frasassi Natural Regional Park, 33T 327215 E 4788555 N.; rel. 24: from Allegrezza et al. 2020 Tab. S1 rel. 25, Mt. Catria (PU), Monte Catria Group, 33T 313272m E 4812637m N.; Rel. 25: 30/05/2016, Mt. Catria (PU), Monte Catria Group, 33T 313497m E 4812032m N.; rel. 26: 01/08/2016, Pian delle Mele - Guardiagrele (CH), Majella National Park, 33T 431600m E 4669940m N.; rel. 27: 01/08/2016, Pizzoferrato (CH), bordering the Majella National Park, 33T 436463m E 4641700m N.

Appendix III – Data source from Table 1

Column 1: *Junipero hemisphaericae-Pinetum nigrae* Biondi et Allegrezza 2020 [(from Allegrezza & Biondi (2020), Table S1, rels 1-6)], Campo Imperatore plateau (Gran Sasso e Monti della Laga National Park, central Apennines); column 2: *Orthilio secundae-Pinetum nigrae* ass. nov. (present paper); column 3: *Digitalidi micranthae-Pinetum nigrae* ass. nov. (present paper); column 4: *Genisto sericerae-Pinetum nigrae* Bonin 1978 [(from Bonin (1978), Table 27, rels: 111, 112, 114, 118, 122, 123)]. Mount Pollino (Pollino National Park, southern Apennines).

Supplementary material

Tables S1–S3

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Data type: tables

Explanation note: Table S1: *Orthilio secundae-Pinetum nigrae* ass. nov., subass. *typicum*, *amelanchieretosum ovalis* subass. nov., *saniculetosum europaeae* subass. nov.; Table S2: *Digitalidi micranthae-Pinetum nigrae* ass. nov., *Cephalanthera longifolia* variant; Table S3: *phi* coefficient value of species for each *Pinus nigra* subsp. *nigra* community type.

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